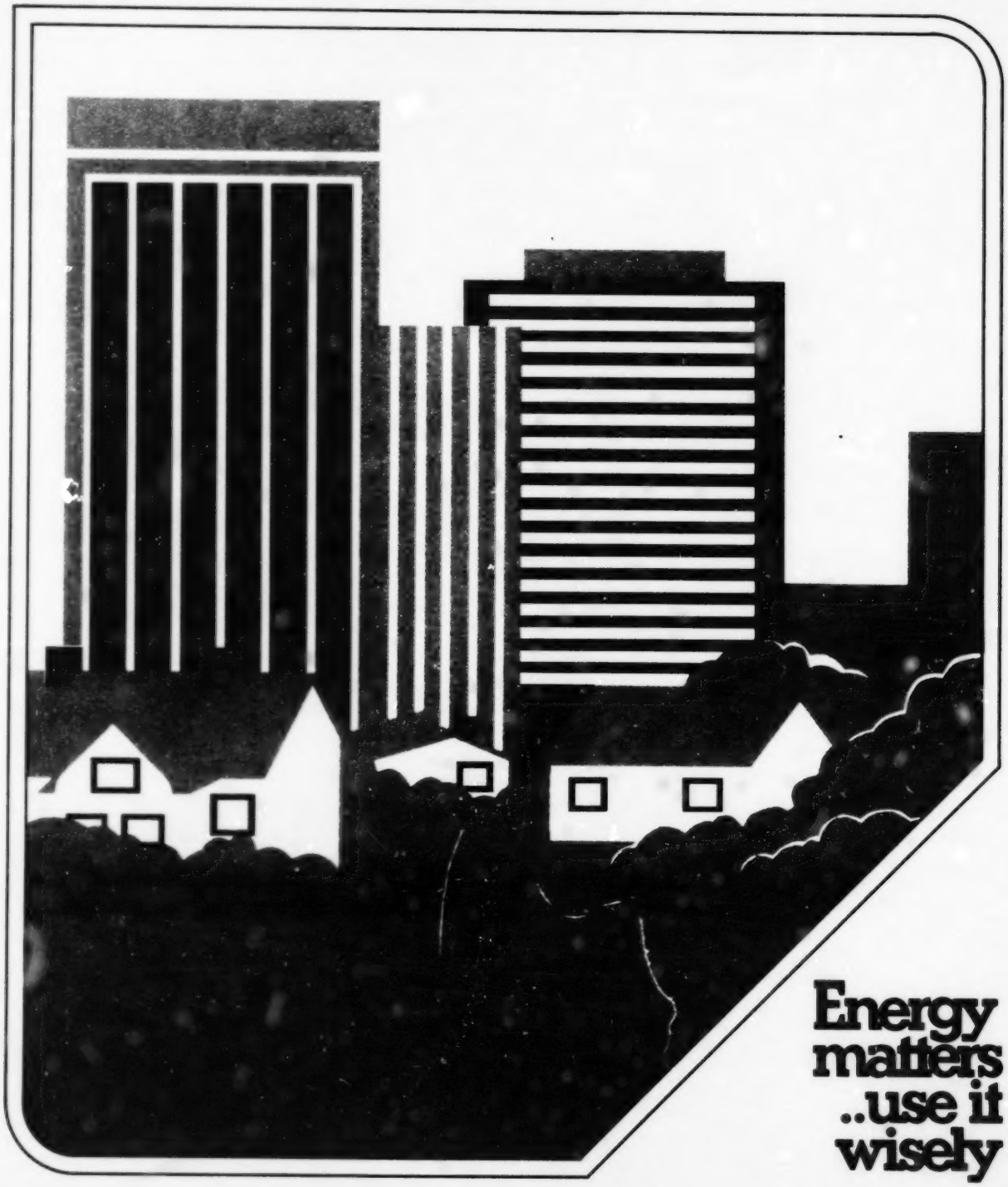
Energy Management in Municipal Water and Wastewater Systems

Alberta

ENERGY AND
NATURAL RESOURCES
Energy Conservation Branch



Energy matters ..use it wisely

A GUIDEBOOK

ENERGY MANAGEMENT IN MUNICIPAL WATER AND WASTEWATER SYSTEMS

Prepared by
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INTRODUCTION

During the period 1976 to 1981, towns and cities in Alberta experienced rapid growth in population associated with the buoyant provincial economy. Preliminary estimates of 1981 Census of Canada data indicate that percentage population increases ranged up to 488 percent for municipalities of 1,000 or more inhabitants (only a few experienced population decreases over that same period). During this same period the rate of inflation averaged about 10 percent/year and energy prices increased 215 percent.

The influx of people and businesses into municipalities usually meant that existing services had to be expanded. In most cases, rapidly expanding tax bases and adequate transfer payments from the provincial government could be used to meet capital and operating requirements.

However, since 1981, economic conditions have changed. While the rate of inflation has fallen and energy price increases have not been as high, many municipalities find their tax base shrinking. With increased public pressure for municipal fiscal restraint, municipalities find the prospect of raising taxes to meet operating costs very unpopular. Consequently, municipal councils have had to consider reducing or totally eliminating certain services, in order to control operating costs.

The management of energy use is one area where municipal operating costs can be controlled without having to reduce or eliminate services. The purpose of this document is to review energy management opportunities in municipal water and wastewater systems. This is one municipal service where the use of energy, and consequently costs, can be quite high.

HOW TO USE THIS GUIDEBOOK

This guidebook is intended to give you an idea of how to reduce your operating costs. It will only be effective if you use it. It is divided into three sections: energy management considerations for the administration, operation, and design of municipal water and wastewater systems. The sections are intended for those who have different responsibilities in regard to operation of these systems.

The **administration section** should be of interest to individuals who have responsibility for overseeing the management of these facilities. This section includes a review of energy use and costs associated with municipal water and wastewater systems, creating an energy management program, energy management concepts for those who will be administering such programs, and finally, a look at some organizations which can advise municipalities about energy management.

The **operations section** is for those people who operate and maintain municipal water and wastewater systems. Energy management techniques appropriate to the operation and maintenance of systems are discussed. These techniques can be implemented at no cost or very low cost. This includes process adjustments, pump operation and maintenance adjustments, lighting, heating and ventilation adjustments, and in some cases, power factor correction and the use of high efficiency motors.

In the last section, **energy management considerations in the design of new systems**, and the renovation and upgrading of existing ones, are discussed. This section contains useful information that municipalities and their design consultants should be aware of when existing systems are to be upgraded or new ones designed. This includes energy management considerations for process modification and design, plant hydraulics, high efficiency motors, power factor correction, energy recovery, instrumentation, lighting, heating, ventilation and the building enclosure.

There are two appendices that will be of use in municipal energy management efforts. Appendix A contains a list of useful material that can be consulted for further information on energy management opportunities in municipal water and wastewater systems. Appendix B contains a list of common energy units and conversions.

One should be aware, when using this booklet, that it is *not* a handbook which provides a step-by-step outline of what energy management measures can be utilized and how they should be implemented. Municipal water and wastewater systems will differ according to age, municipal topography, design and type of equipment. Therefore, some energy management measures described in this booklet may not be applicable. However, this booklet should serve as a guide for municipalities in implementing their own useful and effective energy management programs.

A

ADMINISTRATION

ADMINISTRATION Energy Management Considerations

Rising energy prices during the past eight years, and the larger proportion of municipal budgets that are being devoted to energy costs, have become a concern for municipalities in Alberta. Like any other operating cost in the municipal budget, energy costs can be managed effectively.

"Energy management" implies that specific decisions can be taken to reduce energy costs. This includes the reduction of energy use through specific techniques and actions, but it also includes measures which reduce unit energy costs but may not reduce energy use. For example, by reviewing the energy use of a specific facility with their utility company, and comparing that with the type of utility rate the facility is on, some large energy users have managed to save money simply by changing to a better rate. This is one type of energy management function that can reduce energy costs even though energy use does not change.

While managing energy costs is an important goal, one should bear in mind that water and wastewater systems are unique. The provision of public health, safety and environmental protection are the primary functions of these systems and care must always be taken to ensure that these functions are not threatened by energy management modifications. Fortunately, there are a great many things which can be done to reduce energy costs without reducing system performance.

In this section, attention will be directed at municipal water and wastewater system energy use and costs, what can be done to create an energy management program, energy management concepts, and who can assist municipalities in their energy management efforts.

MUNICIPAL WATER AND WASTEWATER SYSTEM ENERGY USE AND COSTS

ENERGY USE

How much energy do water and wastewater systems use? Table 1 provides data on annual energy use and cost for eight selected Alberta municipalities, in 1982.

Water system energy use ranges from 526,000 kWh/year (municipality H) to 17.6 million kWh/year (municipality A). These are for water flows of 198,000 cubic metres/year and 6.2 million cubic metres/year respectively.

Wastewater system energy use ranges from zero kWh/year (municipality F) to 11.7 million kWh/year (municipality A) on a yearly basis. These are for yearly flows of 179,000 cubic metres and 7.3 million cubic metres respectively.

Even in terms of energy used per cubic metre of water treated, there is still a substantial variation. What are the main factors affecting energy use? As one would expect, due to the wide variation throughout the province in the size and design of water and wastewater systems, there is a wide variation in energy use.

TABLE 1
ANNUAL ENERGY USE AND COST (1982)

Municipal Designation	Population ('000's)	Water System				Wastewater System				Total System
		Energy Use ('000 kWh/yr)		Energy Cost ('000 $/yr)		Energy Use ('000 kWh/yr)		Energy Cost ('000 $/yr)		Energy Cost ('000 $/yr)
		Gas*	Electricity	Gas	Electricity	Gas	Electricity	Gas	Electricity	
A	45.6	12,891.6	4,687.9	121.0	180.7	7,317.0	4,375.6	68.7	158.4	528.8
B	5.6	1,137.9	819.4	10.6	63.6	813.1	1,757.9	8.5	131.3	214.0
C	3.8	121.3	952.6	1.3	39.1	1,403.3	1,032.7	13.9	42.3	96.6
D	2.5	379.3	576.2	4.4	47.9	299.2	36.0	2.4	4.4	59.1
E	2.7	629.2	246.2	5.6	25.3	77.7	92.1	0.7	8.6	40.2
F	2.0	393.3	435.2	4.4	30.5	0.0	0.0	0.0	0.0	34.9
G	1.5	352.1	643.6	3.2	20.6	33.2	40.9	0.3	1.6	25.7
H	1.4	243.6	282.8	2.3	11.4	154.8	188.6	1.3	9.7	24.7

NOTE: This includes all system energy use for pumping, building heat, lighting, etc.
* converted from GJ to kWh units @ 2.77×10^{-7}

Energy requirements for water treatment and distribution systems are dependent upon the volume of water that is pumped, the water distribution operating pressure, municipal topography, the type and level of treatment that exists, and the proximity of the treatment works to the users. Water treatment facilities in Alberta with significant energy use are generally considered to fall into one of two categories:

- complete treatment plants, incorporating flocculation, sedimentation and filtration as the main energy-using components;
- filtration plants, where filtration is the main energy-using component.

In wastewater systems, energy use varies with the volume of wastewater pumped, type of collection system, topography, type and level of treatment and the proximity of the treatment plant to the source of wastewater.

Wastewater treatment facilities in Alberta vary in complexity. Anaerobic lagoons and water stabilization ponds are examples of simple systems which involve minimal energy use. More complex systems with significant energy use generally fall into one of the following categories:

- Aerated Lagoons, in which static aeration is the main energy-using component;
- Extended Aeration Plants, in which screening, comminution, aeration, clarification and aerobic digestion are the main energy-using components;
- Rotating Biological Contactors, in which screening, comminution, clarification, rotating discs and aerobic digestion are the main energy-using components;
- Oxydation Ditches, using screening, comminution, aeration, clarification and aerobic digestion as the main energy-using components;
- Conventional Activated Sludge, in which comminution and aerated grit removal are the main energy-using components.

While it is difficult, without doing energy audits, to make specific judgements on why there are differences in energy use between municipalities, some general comments are in order. For energy use in the water systems of municipalities A and H in Table 1, the difference is partially based on population and therefore the flow rate. Other factors such as age of the equipment will also play a role.

The difference in energy use for municipal wastewater systems A and F is again related to population and flow rate. However, municipality F has a simple gravity flow wastewater collection system and anaerobic lagoon treatment system. Municipality A has wastewater pumping facilities and a mechanical treatment plant.

ENERGY COSTS

Energy costs, of course, also vary. Data on the cost of energy to operate eight municipal water and wastewater systems can also be found in Table 1. Water system energy costs range from $13,700/year (municipality H) to $302,000/year (municipality A). Wastewater system energy costs range from no cost for municipality F to $227,100/year (municipality A). The variation in costs depends on the amount of energy a system uses and the local rates for gas and electricity.

TABLE 2
WATER AND WASTEWATER SYSTEM ENERGY COSTS AS A PERCENTAGE OF MUNICIPAL ENERGY COSTS, 1981

Municipal Designation	Water and Wastewater System (%)
Northern Alberta	
L	20.7
S	28.5
Central Alberta	
C	12.6
G	15.1
J	23.3
M	9.9
N	17.6
O	18.8
P	19.5
Q	24.1
V	5.5
W	12.7
X	4.1
Y	23.1
Southern Alberta	
A	27.6
B	25.8
D	33.8
E	9.2
F	17.0
H	42.9
I	38.6
K	20.4
R	17.4
T	12.5
U	28.6

Source: Unpublished data, Alberta Energy and Natural Resources, Energy Conservation Branch, Edmonton.

Although there is no consistent relationship between the amount of gas and electricity used (that is, the amount of one energy form used is not consistently higher than the other), there is a definite relationship between the cost of gas versus the cost of electricity used. Municipalities typically pay much more for electricity used than for natural gas. This is due to the fuel mix demanded by the nature of the process, and the cost of electricity. In most parts of Alberta, the cost of electricity ranges anywhere from four to eight times higher than natural gas on a heat equivalent basis.

The higher cost of electricity is very evident when comparing energy use and costs for municipality B and E water systems. Gas use is 2.5 (municipality B) and 1.4 (municipality E) times geater than electricity use, but electricity costs are four and six times greater, respectively. This type of energy cost assessment is useful in showing, on a preliminary basis, where a municipality should direct its efforts.

Finally, higher energy costs which municipalities have incurred in order to operate water and wastewater systems are reflected in municipal budgets. Table 2 provides an indication of what proportion of municipal energy costs are associated with the water and wastewater system. For these 25 municipalities, water and wastewater system energy costs range from 4.1 percent to 42.9 percent of municipal energy costs. The average is approximately 20 percent.

THE NEED FOR ENERGY MANAGEMENT

Evidence in the previous section indicates that energy management efforts directed at municipal water and wastewater systems should definitely be considered as a means to control costs. This is important for two reasons. First, the control of operating costs, of which energy is one component, is one way of avoiding increases in local property taxes. Second, although recent energy price increases in general have not been as great, it is expected that electricity will continue to rise in cost during the 1980s. This is due to the fact that large increases in electric generation and distribution capacity, which will be completed during this decade, must be paid for. In addition, projections of world oil supply and demand show there is a distinct possibility of a tight supply situation developing again, around 1990. If this should occur then large oil price increases, and subsequent price increases in other forms of energy, could once again result.

Now is the time to be seriously considering the development of a municipal water and wastewater system energy management program. At the present time, there are already at least 10 municipalities in Alberta which have responded to the challenge of energy cost reduction in the operation of their water and wastewater systems by creating an energy management program.

These municipalities have instituted measures such as:

- insulating water treatment tanks
- personnel awareness programs
- improved equipment maintenance
- installation of time clocks
- roof insulation
- caulking and weatherstripping of the building enclosure
- installation of high efficiency motors
- ventilation heat recovery
- utilization of variable-speed drives
- digester gas utilization
- water conservation programs.

WATER CONSERVATION PROGRAM

The Town of Hanna implemented an experimental water conservation program on a limited number of houses in the summer of 1982. Water consumption during July and August was compared to the previous three summers, and the average saving was found to be 31 percent. At this rate, Bill Ashton (Palliser Regional Planning Commission) calculates that the town could save enough money on energy and chemical costs at its water treatment plant in one year to pay for the installation of water-saving devices in all households in Hanna.

CREATING AN ENERGY MANAGEMENT PROGRAM

Energy management consists of two interrelated components. Management implies the application of sound administrative techniques to the control of unit energy costs. The other component, conservation, is more concerned with the reduction of energy use by operation, maintenance and design techniques. Both are interdependent because a valid technical energy management measure must also be economically feasible.

The implementation of energy management measures, without a program, can proceed in many types of organizations. However, this sometimes creates sporadic efforts and results. A planned programmatic approach should result in more significant short- and long-term benefits. This section outlines how you can create an energy management program in your municipality.

MANAGEMENT COMMITMENT AND ORGANIZATION

The most important element in the initiation and conduct of an energy management program is solid management and political commitment. Regardless of the size or nature of the municipal organization, elected representatives and municipal managers must exhibit leadership and interest if a program is to succeed.

It is worthwhile to create an energy management committee to improve communication and the commitment of others. The size and structure of the committee will vary with the size and complexity of the municipal organization. The committee should be co-ordinated by a member of the municipal administration or the public works department. This individual should be responsible for the overall co-ordination of the program.

Other members of the committee could include operating and maintenance personnel, a member of the municipal council, representatives of the local utilities, and perhaps the municipal water and wastewater system design consultant. The latter two representatives need not have permanent representation on the committee. However, it would be useful to notify them of what the municipality is doing and that their expertise may be required. A council member is also an important representative, particularly in smaller communities, since he or she can provide council input.

In large municipalities, the water and wastewater system energy management organization could be a subcommittee of the public works, engineering or municipal energy management committee. In this case, the co-ordination of the committee, committee representation, and the person to whom the committee reports may be somewhat different.

PROGRAM RESPONSIBILITY

The planning and conduct of the energy management program should be the responsibility of one person. In small municipalities it could be the responsibility of the municipal administrator or town engineer. In larger municipalities, an individual in the water and wastewater department may be a more appropriate choice. Whoever that individual is, they should be fully responsible for the program and have the resources available to operate the program effectively.

It should be noted that the participation and role of operations and maintenance personnel is extremely important in technical retrofits, since it is these people who are involved in the day-to-day operation and maintenance of the water and wastewater system. Therefore, regular consultations between operations staff and the energy management co-ordinator are important.

PROGRAM GOALS

Before setting goals, conduct a preliminary analysis of annual energy use and cost of operating the water and wastewater system. This will give a picture of how energy is currently being used and serve as an indicator of your progress. Goals should be realistic and, if possible, should be measurable. The creation of measurable goals will provide a program target.

The use of standards, such as the number of kWh used per cubic metre of water or wastewater treated and pumped on a yearly basis, can be helpful. For example, this will provide an indication of the amount of energy required to deliver a cubic metre of water to users. Standards can be based on industry experience or theoretical energy requirements. Base year energy use can be compared against current figures, as the program progresses.

One important goal which is not measurable is staff motivation. This requires special attention because staff will be doing something which may require them to change habits and attitudes. At all times the water and wastewater system operating and maintenance staff:

- should have a clear understanding of what is to be achieved
- should be made to feel that they are an integral part of the program
- should be made aware of program achievements and perhaps at some point set their own goals
- should feel that their suggestions and concerns will be listened to
- should have all energy management measures explained to them before implementation.

Staff motivation can "make or break" an energy management program. Although this is a goal which is not measurable, it is perhaps the most important one. Some ways to motivate people include:

- distribution of posters
- light switch stickers
- employee-generated energy management slogans
- energy management suggestion boxes
- competitions between different groups of staff.

Check with utilities or government agencies to see if posters and light switch stickers are available. These suggestions, and others, should assist in motivating people.

CHECK YOUR UTILITY BILLS

The first step in the implementation of an energy management program is the energy audit. An audit can take many forms, but it essentially consists of surveys and data collection stages. An audit will require the time of the program administrator and the operating and maintenance staff.

The program administrator should begin by reviewing utility bills for all sources of energy used by the water and

wastewater system (natural gas, electricity, propane,fuel oil, diesel fuel). Utility bills are the most important source of information on energy use and cost. This information is usually available on a month-to-month basis, although some facilities may be billed once every two months.

If the municipality's utility records are incomplete, contact the local utility office, which should be able to provide assistance.

Utility bills provide basic information on energy use and cost. The following information can be found on most bills:

- account number
- billing period
- number of days in billing period
- amount of energy used
- demand
- fixed charge
- demand charge
- energy charge

Some comment on each of these components is worthwhile.

The account number can usually be found at the top or bottom of the bill. You will require this number if there is a need to contact the utility for further information.

The billing period and the number of days in that period indicate the timeframe over which energy consumption has been measured. In most cases this period is not consistent with the beginning or end of a month. When deciding to allocate energy use to a particular month, a handy rule-of-thumb is to allocate it to the month where most of the billing days occur.

The amount of gas or electricity used (or consumption) can usually be located somewhere near the top of the bill. This figure represents the amount of electric energy or gas consumption during the billing period. Units commonly used include:

- electricity - kilowatt hours (kWh)
- gas - gigajoules (GJ)
  - thousand cubic feet (MCF)
  - million British thermal units (MMBtu)
  - therms (T)

Consumption is calculated by taking the difference between the present and previous meter readings. The difference is multiplied by the appropriate meter multiplier factor to get consumption.

Energy demand is another component usually found on electric utility bills but not on gas bills. Only extremely large users of natural gas are on a demand rate. Most water and wastewater system facilities in Alberta are not in this category.

Demand is the rate at which energy must be supplied to a user. The utility must provide power to all the user loads at any given time (including peak hours). This demand is expressed in units of kilowatts (kW) or kilovolt-amperes (kVA) and is associated with a given monthly period. The utility's thermal demand meter monitors total electrical load on a continuous basis, but takes some time to adjust as the load changes (it takes 15 minutes for 90 percent of the connected load to be recorded by the demand meter so equipment turned on and off again quickly will not register fully). The highest demand measured over the month is used as a basis for the demand charge.

Charges found on the utility bill are to compensate the utility for a variety of costs. The fixed charge is to compensate the utility for customer services such as metering and billing. The demand charge is to recover the cost of having sufficient generating and distribution capacity to meet peak loads. Lastly, the energy charge varies depending on how much energy is consumed and reflects the utility's variable costs.

As noted previously, the utility bills are an important source of information which a program administrator should consult. Pay careful attention to them, they are an invaluable record of a municipality's energy use and cost. If you do not understand your utility bills, consult your local utility office to clear up any questions. Program administrators should note that it is very important for operating and maintenance staff to understand utility bills.

PROGRAM IMPLEMENTATION

Once a utility bill analysis has been completed, the program administrator could have an energy audit performed to find out where energy is being used. One way of getting an early indication of energy management opportunities is to have the Energy Bus do an audit of your facilities. This service is provided by the Energy Conservation Branch, Alberta Energy and Natural Resources. More detailed audits can be performed by engineering consultants. Your utility company may also offer an audit service.

In order for an energy management measure to be considered for implementation, it must be economically feasible. Once no-cost and very low-cost measures have been exhausted, the program administrator should begin carefully evaluating the economic feasibility of higher cost measures. A discussion of useful financial analysis techniques can be found in *Financial Analysis of Conservation Measures (Booklet #5)*. This is part of the series, *A Guide to Municipal Energy Savings*, and is available from the Energy Conservation Branch, Alberta Energy and Natural Resources (see address on page 12).

Program administrators should bear in mind the trade-off between capital and operating costs. This is particularly important in the development of a new physical plant and major additions to existing systems. The main issue is that municipalities only pay a portion of capital expansion while other levels of government pay the remainder.

However, municipalities pay 100 percent of energy costs. Therefore administrators should remember that capital expansion plans should include a very serious consideration of energy efficiency. In most cases it is far easier, and less costly, to design energy efficiency features into a new facility than to retrofit an existing one.

Once the program is in progress a monitoring function should be implemented. Energy use and costs should be reviewed on a regular basis. As noted previously, an index of energy-use efficiency (kWh/cubic metre water treated, for example) may be a useful way of keeping track of program effectiveness. Any sudden change in the index from a base year could highlight the existence of possible problems, or illuminate the success of the program.

ENERGY MANAGEMENT CONCEPTS

This section has been included to orient program administrators to the technical measures which operating and maintenance staff and system designers should be considering. This is not a complete list of all measures that can be performed, but gives an indication of the range of actions which may be available:

ENERGY MANAGEMENT MEASURES

- shut down non-essential equipment when not required
- control of air supply to aeration systems
- adjust solids retention time in the activated sludge process
- use of multiple pumps or variable speed pumping to meet operating requirements
- improved pump maintenance
- sewage forcemains and watermains should be cleaned regularly to reduce pipeline friction loss
- reduce water losses by repairing leaky mains and hydrants
- use high efficiency motors
- evaluate electrical load structure and consider using the stand-by electric generator to shave peak short-term electric demand
- power factor correction
- replace existing lighting with a more efficient type where justified
- consider installing additional switching to achieve better control of lighting
- utilize temperature setback at night, in winter, and in areas which are not frequently used
- hot and cold lines should be insulated to reduce losses
- heat loss through the building enclosure can be reduced by adding insulation
- heat loss attributable to air leakage can be reduced by minimizing these leaks
- ventilation heat loss can be reduced by carefully defining the ventilation requirement and not exceeding it
- maintain efficiency of furnaces and boilers by regular maintenance checks
- minimize heat stratification by using ceiling fans
- consider insulating large vessels containing cold water (e.g., water treatment plants)
- implement a municipal water conservation program to reduce pumping costs

GOVERNMENT ADVISORY PROGRAMS

When considering implementation of a municipal water and wastewater system energy management program, there are organizations which can provide advice or literature on a wide range of energy management matters.

PROVINCIAL

The Energy Conservation Branch, Alberta Energy and Natural Resources, can provide literature and advice on municipal energy management matters. They provide a series of booklets entitled *A Guide to Municipal Energy Savings*, which describe how municipalities can save energy in their entire operations. This branch also manages the Energy Bus audit program. Inquiries can be directed to:

Alberta Energy and Natural Resources
Energy Conservation Branch
Highfield Place, 2nd Floor
10010 - 106 Street
Edmonton, Alberta
T5J 3L8 (403) 427-5200

The Municipal Engineering Branch, Alberta Environment, can also provide assistance with problems related to the operation of water and wastewater systems. Formal programs include:

- Water and Wastewater Systems Operator Training Program
- Water and Wastewater Systems Operator Certification Program
- Field Inspection Program (for municipalities having water supply and wastewater treatment problems).

The branch is available as a resource for municipalities. **It is suggested that any water and wastewater treatment process control energy management measures should be checked out with the branch.** Inquiries can be directed to:

Alberta Environment
Pollution Control Division
Municipal Engineering Branch
5th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6 (403) 427-5837

FEDERAL

Energy, Mines and Resources Canada can also provide information on literature and programs that are available from the federal government. Inquiries can be directed to:

Energy, Mines and Resources Canada
Grandin Park Plaza, Room 200
22 Sir Winston Churchill Avenue
St. Albert, Alberta
T8N 1B4
(403) 420-4036
1-800-222-6477 (Toll Free Number)

UTILITY COMPANY SERVICES

Utility companies are also useful sources of information. Both gas and electric utilities can provide information on your account, such as an explanation of billings and rates. In some cases, inspection services are also provided.

Energy users not served by a municipal utility should contact the utility company's nearest field office.

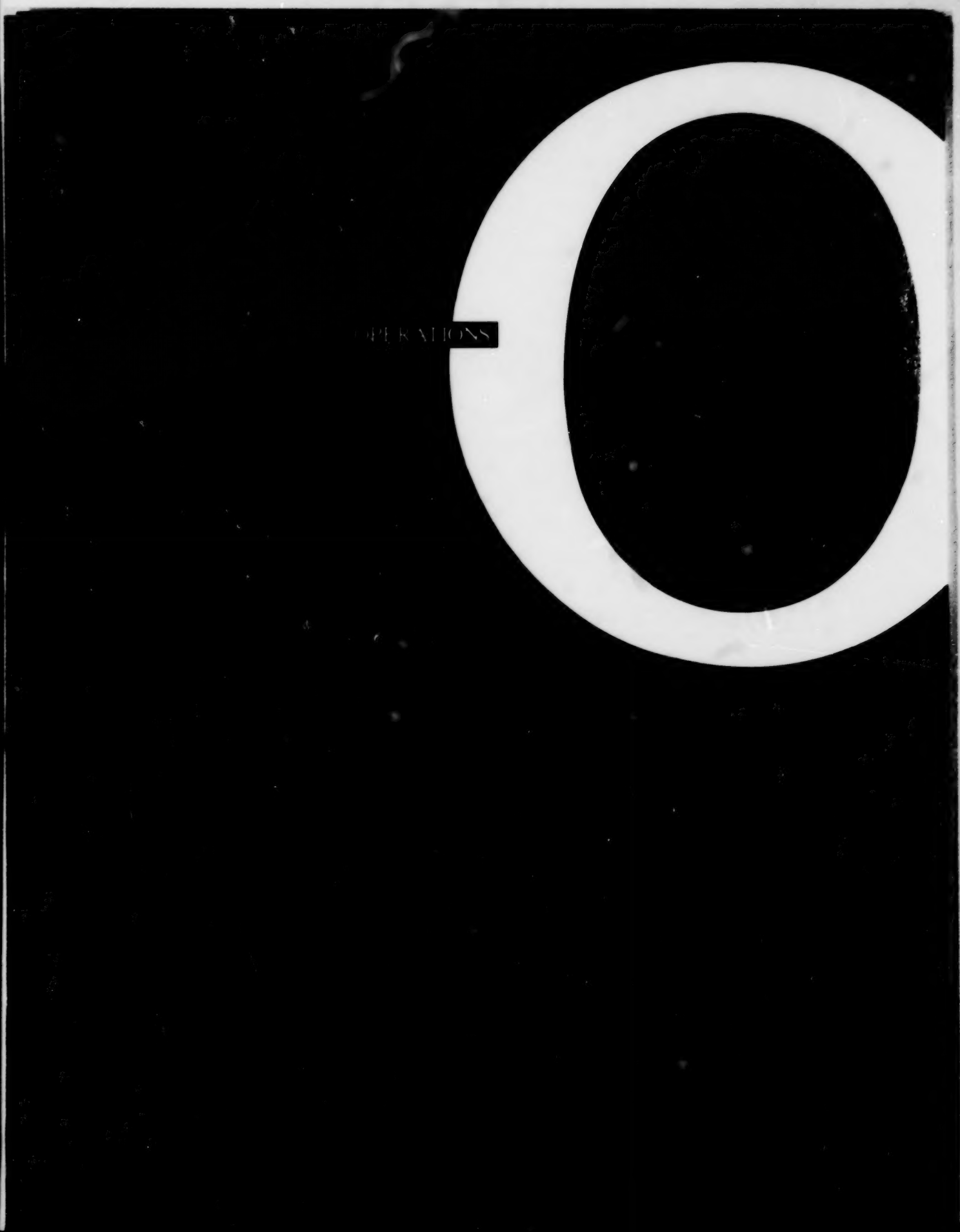
Specific energy management services are offered by some utilities. Most utilities have focused their energy management efforts on the residential sector. This is particularly true of the gas utilities. However, some electric utilities offer energy management services such as:

- power factor assessments
- thermographic building envelope inspections
- walk-through energy audits
- energy management publications
- energy management seminars

You should contact your utility to find out if they offer these services.

SUMMARY

This should provide a basis from which municipalities can initiate an investigation of water and wastewater system energy use and costs. With rising energy prices and municipalities having to control operating costs, energy management opportunities in the municipal water and wastewater system should not be overlooked.


OPERATIONS

OPERATIONS Energy Management Considerations

This section describes energy conservation measures that can be easily and successfully implemented by municipal operating staff at existing facilities.

The areas of potential energy savings in existing water and wastewater systems are numerous and usually consist of no-cost or low-cost items. No-cost measures require no capital expenditure to achieve an energy saving. These include such measures as process adjustments, pump operation adjustments and proper pump maintenance. The low-cost improvements described in this section involve minor capital expenditures which are paid back in energy savings within a few years. High-cost measures normally involve extensive changes and most often require specialists' analyses. These items are described in the following section on design as they are normally beyond the scope of the duties of plant operations staff.

Please note that the discussion of the building enclosure has been left to the design section since it is an area where operators may also require some specialized assistance.

Of course, energy management begins with understanding your facilities, and carrying out proper maintenance and operating procedures as required by the system's designer.

In many cases, present approaches used in the operation of water and wastewater systems do not concentrate on energy management. This is largely due to the fact that many of today's approaches were developed in past years when energy was relatively inexpensive. With today's rapidly increasing energy costs, owners and operators must be aware of the potential for energy management.

PROCESS ADJUSTMENTS

Process adjustments should be aimed at optimizing the efficiency of existing equipment to reduce energy use to a minimum. Specific examples are described below.

Energy management measures which affect the treatment process should be checked before implementation with Alberta Environment's Municipal Engineering Branch (for address see page 12).

SHUTTING DOWN NON-ESSENTIAL EQUIPMENT

During the early years of a facility's life when the design flow rate has not yet been achieved, process units can be shut down as long as the required treatment efficiency is achieved by the units still in operation. For example, in a water treatment facility which has two flocculation basins, if only one flocculation basin is needed then the second should be left out of operation until it is required.

AERATION SYSTEMS

The largest energy consumer in a typical activated sludge wastewater treatment plant is the aeration system used in the aeration tanks and aerobic digesters. There is significant potential for energy savings in this process. By controlling air supply blower output to maintain the dissolved oxygen level at the minimum required for adequate treatment, substantial energy savings can be realized.

The blowers used in the aeration system are either positive displacement or centrifugal type. The output of a positive displacement blower can be controlled by adjusting the blower speeed. On belt driven blowers, sheaves can be changed at low cost to reduce output and required input horsepower. If several blowers have been provided then output can be reduced by turning off one or more units.

The output of a centrifugal blower is controlled most easily by throttling the blower suction or discharge valve. Normally, valving will already be in place and, therefore, there is no expenditure required to make these adjustments. Throttling of the blower suction valve results in a greater energy saving than throttling of the discharge valve for the same reduction in output. However, if there is only a discharge valve in place, then it should be used to reduce the output rather than installing a suction valve. The operator should also refer to the operating information on the blower so that surge conditions are not created in the blower. If surging does occur, severe damage may be caused to the compressor. The effects of blower output adjustments can be easily monitored by determining dissolved oxygen levels within the aeration tank or aerobic digester. Control of the blower then becomes a matter of adjusting the blower output to achieve the desired dissolved oxygen level.

If the proper valving is in place, the operator should adjust the air distribution within the tank so that the dissolved oxygen level is uniform throughout the tank. This would eliminate the need to over-aerate one area of the tank in order to maintain the desired minimum dissolved oxygen level in another area of the tank. The same sort of adjustment should be made where two tanks are supplied by one air supply system.

ADJUSTING SRT IN THE ACTIVATED SLUDGE PROCESS

Adjustment of the Solids Retention Time (SRT) in the activated sludge process can reduce energy consumption. A shorter SRT results in a lower energy requirement. However, as the SRT is decreased the sludge production increases, requiring an increase in energy for sludge digestion and disposal. If the sludge treatment system is a low energy use system then a net decrease in energy use should result. The operator should refer to the plant's operating manual for the allowable range in SRT which can be used and adjust the SRT within this range only.

PUMP OPERATION ADJUSTMENTS

During low flow periods or during the period before design capacities are reached, it may be possible to save energy by throttling centrifugal pump discharges. This creates an artificial head on the pump, forcing it to operate at a reduced capacity. Due to the characteristics of centrifugal pumps, the input horsepower is normally decreased. For continuous duty pumps, the actual electrical savings will depend on the effect this measure has on the pump's operating efficiency. If the pump operates on an intermittent basis then the estimate of the possible electrical savings must take into account the longer operating hours due to the lower flow rate. Any electrical savings generated will be at no capital cost. When dealing with the pumping of liquids containing solids, it is generally not advisable to throttle the pump discharge valve since this may result in plugging. The operator should also avoid throttling any valve to the point that cavitation occurs in the valve as this could cause severe damage.

If a pump is to be operated at a flow much less than its design capacity for an extended period of time, a low-cost smaller impeller should be installed. This results in more efficient operation and, therefore, reduces power consumption more than throttling.

Wet well levels in pumpstations should be maintained as high as possible to minimize static pumping head. In sewage pumpstations, if practical, inlet sewers can be allowed to surcharge in order to operate the wet well at a higher level, but the possibility of solids deposition resulting in sewer plugging must be examined before this measure is put into practice.

Where several different pumps exist in a pumpstation, if practical, the pump sequencing should be arranged so that the most efficient pumps are used first. Where small and large capacity pumps exist in the same pump station, this measure is not practical, since using the largest pump first will result in it operating for only a very short duration when flows are very low. This will cause frequent cycling and may lead to overheating.

PUMP MAINTENANCE

Proper pump maintenance can result in energy savings with no capital expenditure. Attention should be paid to the following:

- worn pump impellers and casings will lower pump efficiency. The original efficiency can often be restored by installing or replacing wear rings;
- pump packings should be properly adjusted to eliminate binding of the pump shaft;
- electrical contacts should be kept clean to reduce losses;
- start/stop controls should be adjusted to avoid unnecessary cycling of pumps.

WASTEWATER COLLECTION AND WATER DISTRIBUTION SYSTEMS

Energy savings can be realized in wastewater collection and water distribution systems by ensuring that wastewater forcemains and watermains are cleaned regularly to keep pipeline friction losses as low as possible.

Valves within the system should be checked to ensure that they are fully opened. Air release valves should be checked to ensure that they are functioning correctly to reduce friction losses due to air entrapment in the system.

In water distribution systems, bleeding between pressure districts should be avoided. Systems should be operated with pressure as low as is practical while maintaining an acceptable level of service.

HIGH EFFICIENCY ELECTRIC MOTORS

High efficiency motors have become available in sizes as small as 0.75 kW (one hp). The improvement in efficiency of these motors over standard motors ranges from approximately eight to ten percentage points for 0.75 kW (one hp) motors to approximately one to three percentage points for 75 kW (100 hp) motors.

High efficiency motors are generally 15 to 25 percent higher in price than standard motors. However, in the case of continuous duty motors this extra capital cost is usually paid back in about two to four years of energy cost savings depending on power rates and motor load.

When replacing worn out standard motors which were operated continuously, high efficiency motors should be considered since the extra capital cost is recovered quickly in power cost savings. On the other hand, replacing motors which still have useful life remaining is generally not cost effective. Also, replacing intermittent duty motors with high efficiency motors is not usually cost effective because the payback period for the extra capital cost is extended, since the hours of operation are less.

REDUCTION OF PEAK ELECTRICAL DEMAND

The demand component of a utility bill is a measurement of the rate at which energy must be supplied to a user. Because the utility must provide power to all user loads at any given time (including peak hours), demand is measured

and charged for. In some cases the total demand charges can be more than the total energy consumption charges.

Peak electrical demand can be reduced through several no-cost or low-cost measures. The savings which will result from reducing peak demand depend on the particular electric rate that the facility is on, and the profile of daily, monthly and annual electric energy use. If the rate structure emphasizes demand charges, and if the facility has short duration high peak electrical loads which establish the demand billed for, then savings could be substantial. Any measure that conserves energy should reduce peak usage, however specific measures to reduce peak usage are as follows:

- Low-cost interlocks or timers can be incorporated into the motor controls to avoid the operation of non-essential equipment during peak demand periods. For example, electric heaters could be shut off during periods when process equipment must be run at peak capacity to meet the process demand.
- If the plant has an emergency electrical generator, this can be used during peak electrical use periods to shave the peak electrical demand. However, the saving in peak electrical charges would have to be weighed against the cost of fuel used to operate the emergency generator. Capital costs may also be necessary for controls which must be approved by the utility to permit parallel operation of the generator with the grid electrical supply.
- Engine-driven pumps which are in place to provide standby capacity during power failure can be used during peak pumping periods in place of electrically driven pumps. Again, the savings in electrical demand charges would have to be weighed against the cost of fuel used to operate the engine drives.
- It may be possible to reschedule certain processes to times of the day when other equipment is not functioning so that peak electrical usage is lowered. For example, if practical, pumping to an elevated water storage reservoir should be scheduled for off-peak hours.

LIGHTING

Lighting may account for up to 50 percent of the non-process electrical load in water and wastewater treatment facilities. In many plants lighting systems have been designed to provide more light than required for specific tasks. The easiest and most economical method to overcome this is to turn lights off or de-lamp light fixtures to provide only the level of lighting necessary to maintain safety and staff efficiency.

Equipment such as fluorescent and mercury vapour lamps will still have ballast losses if only the lamp is removed. This amounts to about twenty percent of the normal operating draw of the fixture and it is, therefore, better to disconnect these types of lamps.

Switches can be incorporated into lamp wiring circuits quite inexpensively to allow illumination of individual areas or rooms only when needed to perform a specific task.

The efficiency of lighting systems should be kept at maximum by regularly cleaning fixtures and lamps.

HEATING AND VENTILATION

In heating and ventilation systems possible energy conservation measures are similar to those used in other types of buildings.

Room temperatures should be reduced as much as practical but still allow efficient operation of equipment and personnel comfort. Temperatures can be further set back when the building is unoccupied such as overnight and on weekends.

Hot water tanks and lines should be insulated to reduce heat losses.

Ventilation rates should be reduced as much as possible to avoid the unnecessary heating of outside make-up air. This could extend as far as shutting off ventilation systems when the building is unoccupied. However, the minimum ventilation rate employed must maintain a safe working atmosphere for occupied facilities.

Air filters on all ventilation equipment should be kept clean to reduce losses in the air distribution system.

Simple, low-cost conservation measures for the plant building enclosure are summarized in Table 3. Many of these are discussed in more detail in the next section.

More specific information on energy management considerations for buildings can be found in *Saving Energy in Municipal Buildings (Booklet #6.)*. This is part of the series *A Guide to Municipal Energy Savings* and is available from the Energy Conservation Branch, Alberta Energy and Natural Resources (see address on page 12).

TABLE 3
BUILDING ENCLOSURE ENERGY MANAGEMENT MEASURES

COMPONENT	PROBLEM	ACTION
Air intakes and exhaust	dampers do not close properly	correct by adjusting damper vanes or installing weather-stripping along the vanes
Windows	air leakage	weatherstrip and caulk around frame and window bottom rails
		keep windows closed during the winter
	broken	replace broken panes
	heat loss	add storm windows where single glazing is being used
		consider stick-on type insulation covering for windows
		consider covering a portion or all of the glazing where it is excessive (particularly north-facing windows)
	heat gain	consider installing window shading devices or solar control window film on south-facing windows
Doors	loose-fitting	consider weatherstripping, installing new threshold, or frame repair
	do not close	check door closing hardware, check door fit, balance intake and exhaust air to correct air pressure problem
	employees do not close doors	install door closure signs for user awareness
	open loading dock doors	install loading dock door seals and ensure bottom of door is weatherstripped
Walls	drafts through wall openings	caulk or seal openings around electrical receptacles, conduit and piping, hose bibbs and vents
	cracks	patch or seal
	heat loss	check for missing or damaged insulation and repair
Ceiling	drafts around exhaust piping or ductwork	caulk or repair flashing
	heat loss	check air-vapour barrier and add insulation
Roof (flat roof)	holes and cracks	patch, cover or caulk. Attention should be directed at the joint between the wall and roof
	heat loss	add roof insulation during major roof renovations

DESIGN

D

DESIGN Energy Management Considerations

This section outlines the basic energy management considerations that both designers and owners should become familiar with in order to design and operate more energy efficient water and wastewater systems.

The guidelines are discussed in terms of new system design. However, some measures could be applied to the retrofit of existing systems, depending on the particular situation.

The practicality of applying the following conservation measures to existing systems will be restricted by the economics of the payback of the capital cost in the form of energy cost savings. Many of the following measures have a high cost and will only be applicable to new system design or major expansions to existing systems.

DESIGN APPROACH

In many cases, present design approaches for water and wastewater systems do not concentrate on energy conservation. This is largely due to the fact that many of today's design approaches were developed in past years when energy was relatively inexpensive. With today's rapidly increasing energy costs, designers must produce more energy conscious designs and owners must be aware of potential considerations for energy management.

In designing new facilities, the different overall process concepts that are available must be examined. For example, in wastewater treatment systems, the rotating biological contactor principle is generally more energy efficient than the conventional activated sludge process. Land disposal methods such as spray irrigation and infiltration are more energy efficient than modes of secondary treatment involving aeration. In water treatment plants, gravity filtration generally uses less energy than pressure filtration.

These process variations must be examined, keeping in mind applicability to a particular situation. However, more emphasis must be placed on the energy requirements of various alternatives when evaluating design options. After the basic concepts for treatment processes have been outlined, designers should concentrate on specific aspects of the process.

Energy management measures which significantly affect the treatment process should be checked with Alberta Environment's Municipal Engineering Branch (for address see page 12).

PROCESS DESIGN

AERATION

The highest user of energy in water and wastewater systems is the aeration equipment. Therefore, much attention should be given to the selection of equipment and design of the controls for the system.

Considerable energy savings can be achieved in aeration systems by more closely controlling blower output to meet the demand of the process. As pointed out in the operations section, the system must have flexibility which allows the operator to vary blower output either by throttling in the case of centrifugal blowers, or changing blower speed in the case of positive displacement blowers. If several smaller blowers are provided, then total air output can be easily varied by turning on or off combinations of blowers.

Automatic dissolved oxygen monitoring systems can be used in conjunction with blower control systems to modulate blower output to closely match demand. This would reduce the amount of operator attention required since manual blower output modulation requires high operator attention in order to maintain close control.

Automatic dissolved oxygen control would therefore increase the energy savings by providing much closer control. Automatic dissolved oxygen control could be implemented in existing systems as well as new systems.

Tanks for mixing should be designed to avoid dead spaces, because dead space requires greater use of energy in the mixing process.

EQUIPMENT LAYOUT

A layout that allows the equipment to be housed in a few large buildings rather than several smaller buildings will reduce building heating and lighting requirements. This measure must be considered in conjunction with maintaining operational flexibility and ease of future expansion. It would not be practical to implement this measure in an existing system since the energy cost savings generated would be very small in comparison to the reconstruction costs.

USE OF ANAEROBIC DIGESTER GAS

Consideration should be given to converting the gases produced in anaerobic digestion of sludge to a more usable form of energy. These gases can be utilized to fire boilers for building and process heat or to run electrical generators or equipment. Sludge gas typically has approximately two-thirds the gross energy value of natural gas and is, therefore, a valuable resource. This measure may be economically added to existing anaerobic digestion facilities.

PLANT HYDRAULICS

Head losses through plants should be minimized to reduce pumping heads upstream and downstream of the plant. In the case of wastewater treatment facilities, excessive head losses through the plant may require that the headworks of the plant be higher in elevation. This results in the raw

sewage lift station being designed for a higher lift. Similarly, raw water pumpstations feeding water treatment facilities would have to be designed for a higher lift if the head end of the plant had to be raised to allow for excessive head losses through the plant. This measure would not be applicable to existing systems as the hydraulics are already determined and modifications would involve major design changes.

Flow equalization should be considered ahead of wastewater treatment facilities to provide a more constant inflow to the plant. This will make it easier to design downstream pumps, blowers and other equipment to operate at the best efficiency points. This will also result in reduced peak demands. Similarly, the variations in demand on a water treatment plant can be smoothed out by incorporating water storage facilities in the water distribution system. The storage facilities can be drawn from during peak demand periods and refilled during low demand periods. Flow equalization and water storage facilities should be considered for both existing and new systems.

Sanitary sewers should be designed for minimum depth of bury and minimum slopes to reduce pumping static lift at the treatment plant.

System pressure in water distribution systems should be designed as low as is practical while maintaining an acceptable level of service.

OPERATIONAL FLEXIBILITY

All designs should incorporate flexibility to allow the operator the opportunity to conserve energy by taking units out of operation during low flow periods. The use of multiple units, rather than one unit sized for peak demand, is preferable particularly if a range of flow rates is anticipated. The use of multiple units will also lower the peak electrical demand since at flows less than the design capacity one of the smaller units can run continuously, whereas a large unit would be cycling on and off at a high rate of power consumption.

PUMPING SYSTEMS

PUMPING SELECTION

Pumping systems are generally the second largest user of energy in water and wastewater systems. Major causes of excessive energy use in pumping systems are the improper selection of pumps and impellers, and the oversizing of pumps and drivers. It is important to accurately analyse the actual operating conditions of the system and then match the pumps as closely as possible to the system to produce an efficient pump selection. Often, margins of safety are added to pump selections. As a result, pumping systems are often overdesigned. To compensate for this overdesign, it is necessary to throttle valves to achieve the desired flow, resulting in greater energy use than would be required by a properly sized system. When pumping liquids containing solids, it is not usually advisable to throttle valves since this would result in plugging. Thus, if these pumping systems are overdesigned the pumps would have to cycle on and off to meet the system demand.

Electric motor efficiency remains fairly high if the load is from 50 to 125 percent of the rated output. However, efficiency drops significantly if the load is less than 50 percent. Thus, when selecting an electric motor, care should be taken so as not to oversize the motor to the point where it may operate at less than 50 percent of its rated output. Designers should also be aware of the fact that the power factor of electric motors drops off quickly as the load drops below 100 percent.

OPERATIONAL FLEXIBILITY

It is essential to have operational flexibility in pumping systems to allow operators to vary outputs to match pump demand. Several pumps should be provided to allow turning off pumps during low flow periods.

Multiple-speed motors should be considered as a means of varying pump output in response to varying demand. Multiple-speed motors are generally as efficient as single-speed motors, however the starters and controls are rather cumbersome in anything over two speeds.

Alternatively, variable-speed drives can be used to very closely match pump output to pumping demand. This is desirable because the exact pumping rate required is often only determined once installation is complete and may vary through the life of the system. Fine tuning is then easily accomplished with a variable-speed drive. The most efficient type of variable-speed drive is the controlled current variable frequency type which can achieve efficiencies up to 85 to 90 percent. Variable-speed drives are expensive and may have higher maintenance costs. They may also require specialized personnel to carry out maintenance. These factors must be considered when selecting a variable-speed drive. A simple type of variable-speed drive, which is also energy efficient, is the variable sheave type.

PIPELINES

When designing new wastewater forcemains and water transmission mains, they should be sized to minimize capital cost as well as operating cost. Smaller diameter pipelines, which are lower in capital cost, result in higher energy costs due to increased friction losses. Small increases in pipeline diameters result in lower operating costs as well as lower capital cost for the pumping facilities.

If larger diameter piping would result in low velocities which would allow solids deposition to occur, two smaller lines operating in parallel should be considered. During low flow periods, only one pipeline could be used to maintain acceptable velocities.

Pig launching and retrieving facilities should be provided in pipelines to allow operators to easily clean out lines in order to keep friction losses as low as possible. These facilities should be considered for new systems as well as existing systems which presently do not have them.

HIGH EFFICIENCY ELECTRIC MOTORS

High efficiency motors should be considered on all new continuous duty equipment. They have become available in sizes as small as 0.75 kW (one hp). The improvement in efficiency of high efficiency motors over standard motors ranges from approximately eight to ten percentage points for 0.75 kW (one hp) motors to approximately one to three percentage points for 75 kW (100 hp) motors. High efficiency motors are generally 15 to 25 percent higher in price than standard motors, however this extra capital cost is usually paid back in two to four years of electrical cost savings depending on power rates, hours of operation and motor load. As described in the operations section, replacement of existing motors which have remaining useful life is generally not cost effective.

IMPROVEMENT IN POWER FACTOR

The significance of electrical power factor is not always recognized. A low power factor means you could be paying a needless penalty on your electrical demand charges. Power factor is the relationship of AC current to AC voltage in a distribution system. All inductive electrical loads, including motors, ballasts and transformers cause the current to lag the voltage when power flows through them. Resistive loads such as incandescent lights and electrical heaters do not exhibit this effect. Power factor can therefore be thought of as a measure of the "efficiency" at which electrical power is used.

Under ideal conditions the power factor in an electrical system should be one, or 100 percent. With normal inductive loads, it can be 80 or 90 percent or less. Inductive loads that are not fully loaded (i.e., motors or transformers) exhibit particularly low power factors. Any facility with an electrical *demand* meter should benefit from power factor improvement. However, the cost effectiveness of specific measures to improve power factor will depend on the exact nature of the electrical rate which the facility is on. Your electrical utility should be able to help in determining this.

A common method of power factor improvement is the installation of capacitors in the system. Capacitors must be installed on the load side of the utility meter to have any effect on the electrical billings. They can be installed in new or existing systems but detailed analysis of the system is required to determine the best location for the capacitors. Capacitors are often connected in parallel with an induction motor. The capacitance that provides the best power factor improvement depends on the motor characteristics so the motor manufacturer should be consulted for advice. Capacitors can also be installed on the primary or secondary side of the transformer to provide power factor improvement to the entire plant load or at a motor control centre to provide power factor improvement to a group of electrical equipment.

High efficiency motors generally have higher power factors than standard motors. Thus, the use of high efficiency motors to reduce electrical consumption has the added advantage of improving power factor.

INSTRUMENTATION

Instrumentation can be used to automatically control energy-using processes. Micro-processors and minicomputers are now becoming inexpensive enough to allow even small facilities to justify their purchase for addition to existing systems or incorporation into new system design.

Automatic control is desirable in situations where extensive operator attention would be required to achieve energy savings through manual adjustments. For example, an automatic control system can be used to monitor dissolved oxygen levels in an aeration tank and can be used to automatically modulate supply air or blower output accordingly.

Electronic controllers can also be used to monitor peak electrical demand. As the peak demand approaches a level that would result in increased peak demand charges, the controller can shut off non-essential equipment or warn the operator that peak demand is being reached. This will aid the operator to more precisely manage electrical loads.

LIGHTING

Lighting levels in plants should be determined by task. Low intensity lighting should be used for general areas with highlighting added to areas where specific tasks will be carried out.

Use of more energy efficient types of lamps should be considered. Various types of lamps and their approximate output in lumens per watt are listed below:

	Lumens per Watt	Lamp Life (000 hrs)
Low pressure sodium	175-185	18
High pressure sodium	95-140	20-24
Metal halide	85-110	7.5-15
Fluorescent	70-80	20
Mercury vapour	31-63	24
Incandescent	15-25	1

For indoor lighting, generally fluorescent lighting or high pressure sodium lamps should be used. For outdoor lighting, high or low pressure sodium should be considered as they are more energy efficient than the commonly used mercury vapour lamps. However, care must be taken in discarding burned-out low pressure sodium luminaires. If a luminaire is broken when it is disposed of the sodium could cause a fire in the garbage bin. Due to the colour rendition of sodium vapour lamps they may not be suitable for all applications. Metal halide lamps which produce a balanced colour spectrum with good colour rendition are the next best choice in terms of energy efficiency.

Natural lighting could be used wherever possible, but this measure must be weighed against the additional heating requirements due to window heat losses, and additional ventilation requirements due to heat gains from the sun.

Building interiors should be light in colour to increase surface reflectance.

Automatic photocell switching for exterior lighting should be considered to avoid having lights turned on when not required.

Ample switching should be provided to allow for turning off unnecessary lights in partially occupied spaces.

HEATING AND VENTILATION

Heating systems should be designed so that the temperature of individual rooms can be adjusted independently to suit occupancy.

Ventilation rates should be reduced as much as possible to avoid the unnecessary heating of outside air. However, the minimum ventilation rate employed must maintain a safe working atmosphere. This is of particular importance in areas such as digester gas floors and chlorination rooms where high continuous ventilation rates are required to expel dangerous gases.

Heat exchangers should be considered to transfer heat from building exhaust streams to incoming fresh air. These may be especially cost effective when used on continuous exhaust systems.

BUILDING ENCLOSURE

The building enclosure consists of the roof, walls (including penetrations such as doors and windows), the floor slab, and below-ground foundation structures. These elements enclose conditioned (heated, cooled, etc.) spaces through which thermal energy is transferred to or from the exterior or to or from an unconditioned space. The main function of the building enclosure is to impede the rate of heat transfer across it. This also includes heat loss due to air infiltration or leakage.

Two primary malfunctions of the building enclosure are air infiltration/leakage and heat transfer losses through the enclosure.

A visual inspection of the building enclosure can be performed by the operating and maintenance staff. Air infiltration/leakage can be found by sight (looking for cracks) or by noting the presence of a draft.

Transfer losses through the enclosure can sometimes be detected by sight or touch if a careful visual inspection of the enclosure is performed. However, a thermographic inspection performed by experts using an infra-red camera could yield better results because damaged or missing insulation in the wall cavity cannot be detected by sight.

AIR INFILTRATION AND LEAKAGE

Air infiltration is the movement of air through cracks and holes in the building enclosure into interior spaces. Air leakage refers to the reverse action — air movement from the inside to the outside.

The correction of air leakage into and out of a building provides two main benefits:

- reduction in the amount of air that must be heated or cooled
- increased comfort due to decreased drafts.

These corrective measures can be implemented by caulking and weatherstripping holes and cracks. A booklet describing different types of weatherstripping and caulk is available from the Energy Conservation Branch, Alberta Energy and Natural Resources. One should bear in mind that any effort to properly seal the building enclosure should also include an assessment of the ventilation

requirements to ensure that ventilation remains adequate. For building enclosure energy management measures, see Table 3 (p. 20).

HEAT LOSS

Heat loss through the building envelope is a major problem in a climate where heating is required during a large part of the year. Because of temperature differences (normally 20 °C in the building space and sometimes as low as -40 °C outside), heat will be transferred by conduction across the building enclosure to areas of lower temperature. One simple way to reduce heat loss is to reduce indoor temperature. For small facilities which are normally unoccupied temperatures can be reduced well below 20 °C in winter months. In other facilities, it may be feasible to install automatic setback thermostats to reduce temperature during unoccupied hours and bring temperatures back up again before staff return.

In the design stage, a heat loss factor to be considered is the placement of windows. Windows can be a major source of heat loss, and may not really be necessary in facilities which are usually not occupied.

Insulation and the vapour barrier in existing facilities should be inspected with respect to heat conduction losses. Where possible an inspection should be performed to determine the condition of the air/vapour barrier and insulation. In wood-frame construction the air/vapour barrier is the heavy plastic lining applied to the studs on the warm side of the insulation. In masonry construction a mastic coating (air/vapour) is applied to the exterior surface of the concrete. Insulation is then applied to the mastic. The air/vapour barrier should be adequate since it will inhibit the movement of moisture from warm interior spaces into the insulation. Any tears or cracks will significantly reduce the ability of the barrier to inhibit water vapour and air movement. Insulation materials must be kept dry. Insulation saturated with water transfers heat approximately 15 to 20 times faster than dry insulation, while insulation which has been saturated with ice transfers heat approximately 50 times as fast as dry insulation.

Moisture damage, along with compaction, compression, and missing insulation are the most common problems with existing structures. These problems can create conditions of extreme heat loss, reduced control of temperature, and discomfort for personnel.

Retrofitting insulation to existing buildings is generally not economical. It only becomes feasible when general building enclosure rehabilitation is being performed. For example, rigid insulation can be added during re-roofing, or insulation can be installed in attics and suspended ceilings. There are also building cladding systems which contain insulation that can be added to the exterior or interior of the building enclosure.

In a design situation special attention should be directed to insulating the building enclosure, as well as hot and cold piping and tanks, since it is easier and much less costly to install in new construction. The analysis of insulation in both retrofit and new design situations should determine the thickness of insulation which is most cost effective; this is a trade-off between installed cost (and in some cases maintenance) and energy costs avoided. In other words, the designer must consider the point at which marginal costs (the cost of adding an extra inch of insulation) equal marginal benefits (the additional energy costs avoided by adding extra insulation).

For measures to reduce conduction heat loss, see Table 3 (p. 20).

APPENDICES

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APPENDICES

APPENDIX A: BIBLIOGRAPHY

Baker, M.C., 1977. *Energy Conservation and Roofs.* Ottawa: National Research Council, Building Practice Note No. 16.

Burris, Bruce E., 1981. "Energy Conservation for Existing Wastewater Plants." *Journal of the Water Pollution Control Federation,* May.

D'Angelo, S. et al, 1980. "Energy Conservation in Activated Sludge Systems." *Journal of the American Society of Civil Engineers, Environment Engineering Division,* August.

Energy, Mines and Resources, Canada, 1982. *Enersave for Municipalities Series, Booklets 1-10.* Ottawa: Supply and Services, Canada.

Energy, Mines and Resources, Canada, 1981. *Municipal Energy Audit: A Practical Guide to the Identification of Energy Expenditures.* Ottawa: Supply and Services, Canada. Building Series Publication #3.

Energy, Mines and Resources, Canada, 1980. *Saving Money in Heating, Cooling and Lighting.* Ottawa: Supply and Services Canada.

Lindhorst, Paul K., 1978. "High Efficiency Motors Generate Substantial Savings." *Water and Sewage Works,* January.

Owen, William F., 1982. *Energy in Wastewater Treatment.* Englewood Cliffs: Prentice-Hall.

Reid, Crowther & Partners Limited, 1979. "Designing an Energy Efficient Waste-Water Treatment Plant." *Water and Sewage Works,* v. 126 and 127.

Saxon, T., 1980. "Energy Savings Can Fit Your Budget." *Water and Sewage Works,* November.

TransAlta Utilities, 1983. *Energy Management: Power Factor.* Calgary: TransAlta Utilities.

TransAlta Utilities, 1983. *Energy Management: Rates and Billing.* Calgary: TransAlta Utilities.

TransAlta Utilities, 1982. *Energy Management: Energy Efficient Motors.* Calgary: TransAlta Utilities.

APPENDIX B: COMPARISON OF ENERGY UNITS AND CONVERSIONS

UNIT	SI METRIC SYSTEM	IMPERIAL SYSTEM	SELECTED CONVERSIONS
HEAT	joule (J) kilojoule (kJ) 10^3J megajoule (MJ) 10^6J gigajoule (GJ) 10^9J	British thermal unit (Btu) therm (100,000 Btu)	1 Btu = 1055 J 1,000 Btu = 1.055 MJ 1,000,000 Btu = 1.055 GJ 1 therm = 105.5 MJ
ELECTRICAL POWER	watt (W) kilowatt (kW) megawatt (MW)	watt (W) kilowatt (kW) megawatt (MW)	1 kW = 1000 W 1 MW = 1,000,000 W kW = kVA x power factor
MECHANICAL POWER	Kilowatt (kW)	horsepower (HP) ton (refrigeration capacity)	1 HP = 0.75 kW 1 kW = 1.34 HP 1 ton = 3.52 kW
WORK	kilowatt-hour (kWh)	horsepower-hour foot-pound	1 HP-hr = 0.75 kWh 1 kW = 3414 Btu 1 kWh = 3.6 MJ 1 ft-lb = 1.36 J
HEAT FLOW	watts/m^2 °C	Btu/ft^2.hr. °F	1 Btu/ft^2.hr. °F = 5.68 w/m^2. °C

SUMMARY CHECKLIST

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SUMMARY CHECKLIST

The following is a checklist of ideas found in this booklet. Please refer to the appropriate page of the text (indicated in brackets) for explanation

ADMINISTRATION

- ☐ Create a water and wastewater system energy management committee. (10)
- ☐ Perform energy use and cost analyses using information from utility bills. (11)
- ☐ If possible, determine the percentage of municipal energy costs devoted to the water and wastewater system. (9)
- ☐ Create definable program goals. (10)
- ☐ Staff motivation effort. (10)
- ☐ Energy audit (Energy Bus or otherwise). (10)
- ☐ Evaluate potential projects identified in energy audit. (11)
- ☐ Implement projects. (11)
- ☐ Monitor progress of the program. (12)

OPERATIONS

- ☐ Shut down non-essential equipment. (17)
- ☐ Maintain proper air supply blower output in aeration systems. (17)
- ☐ Adjust solids retention time in the activated sludge process to the lower end of the allowable range of time. (17)
- ☐ Throttle centrifugal pump discharges in liquid pumping situations. (18)
- ☐ Install smaller impellers in pumps operating below design capacity for long periods of time. (18)
- ☐ Wet well levels in pumpstations should be maintained as high as possible to minimize static pumping head. (18)
- ☐ Consider pump sequencing in pumpstations where several pumps are in use. (18)
- ☐ Check worn pump impellers and casings. (18)
- ☐ Properly adjust pump packings. (18)
- ☐ Keep electrical contacts on pumps clean. (18)
- ☐ Ensure that stop/start controls are properly adjusted. (18)
- ☐ Ensure that wastewater forcemains and watermains are cleaned regularly. (18)
- ☐ Distribution and collection system valves should be checked to ensure they are fully open. (18)
- ☐ Ensure air release valves are functioning properly. (18)
- ☐ Water distribution system pressure should be operated as low as practical while maintaining proper service. (18)
- ☐ Consider installing high efficiency motors, especially when replacements needed. (18)
- ☐ Reduce peak electrical demand by installing interlocks or timers on motor controls. (19)
- ☐ Consider using the emergency electrical generator for peak shaving. (19)
- ☐ Consider using engine driven pumps during peak pumping periods. (19)
- ☐ Consider rescheduling certain treatment processes to non-peak periods. (19)
- ☐ Ensure that lights are turned off when areas are not in use. (19)
- ☐ Consider de-lamping light fixtures. (19)
- ☐ Consider incorporating more switches into lamp wiring circuits. (19)
- ☐ Regularly clean fixtures and lamps. (19)
- ☐ Consider building space temperature setbacks at night and on weekends. (19)
- ☐ Consider insulating all uninsulated hot and cold water lines and tanks. (19)
- ☐ Maintain proper building ventilation levels. (19)
- ☐ Keep air filters on ventilation equipment clean. (19)

DESIGN

- ☐ Maintain proper control of blower output in aeration systems. (23)
- ☐ Install several smaller blowers in order to take advantage of sequencing. (23)
- ☐ Utilize automatic dissolved oxygen control. (23)
- ☐ Avoid dead spaces in tank geometrics. (23)
- ☐ Layout equipment so that a few large buildings can be used instead of a number of smaller ones. (23)
- ☐ Consider utilizing gases produced from the anaerobic digestion of sludge. (23)
- ☐ Minimize head losses through treatment facilities. (23)
- ☐ Flow equalization should be considered ahead of wastewater treatment facilities to provide a more constant inflow to the plant. (24)
- ☐ Incorporate water storage facilities in the water distribution system to smooth out variations in demand on a water treatment plant. (24)
- ☐ Design sanitary sewers for minimum depth of bury and minimum slopes to reduce pumping static lift. (24)
- ☐ System pressure in water distribution systems should be designed as low as practical. (24)

- [ ] Incorporate operational flexibility in design so that units can be taken out of operation during low flow periods. (24)
- [ ] Size and select pumps and impellers properly by accurately analysing operating conditions. (24)
- [ ] Do not oversize electric motors. (24)
- [ ] Consider multiple-speed motors as a means of varying pump output. (24)
- [ ] Variable-speed drives can be used to match pump output to pumping demand. (24)
- [ ] Design new wastewater forcemains and water transmission mains to minimize capital cost and operating cost. (24)
- [ ] Consider two smaller wastewater lines operating in parallel instead of larger diameter piping. (25)
- [ ] Pig launching and retrieving facilities should be provided in pipelines. (25)
- [ ] High efficiency motors should be considered on all continuous duty new equipment. (25)
- [ ] Install capacitors to improve power factor. (25)
- [ ] Consider using micro-processors or minicomputers for process control. (25)
- [ ] Electronic controllers can be used to monitor peak electrical demand. (25)
- [ ] Determine lighting levels by task. (25)
- [ ] Consider use of high efficiency lamps (e.g., high and low pressure sodium, metal halide). (26)
- [ ] Building interiors should be light in colour to increase reflectance. (26)
- [ ] Automatic photocell switching for exterior lighting should be considered. (26)
- [ ] Provide ample switching for lighting control. (26)
- [ ] Design heating systems so that areas have their own temperature control. (26)
- [ ] Reduce ventilation rates consistent with a safe working environment. (26)
- [ ] Consider installing heat exchangers for ventilation heat recovery. (26)
- [ ] Minimize air infiltration and leakage by caulking and weatherstripping. (26)
- [ ] Minimize conduction heat loss by installing adequate insulation. (27)

POOR

QUALITY

ORIGINAL